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CLIMATOLOGICAL DATA FOR JAMAICA.

Through the kindness of H. H. Cousins, chemist to the Government of Jamaica and now in charge of the meteorological service of that island, we have received the following table in advance of the regular monthly weather report for Jamaica:

Comparative table of rainfall for November, 1902.

Divisions.	Relative area.	Number of stations.	Rainfall. Average.	Rainfall. 1902.
	Per cent.		*Inches.*	*Inches.*
Northeastern division	25	21	10.97	9.47
Northern division	22	47	5.85	2.55
West-central division	26	21	6.06	6.42
Southern division	27	32	4.78	3.97
	100	121	6.91	5.60

The rainfall was, therefore, below the average for the whole island. The highest fall recorded was 31.27 inches, at Moore Town, in the northeastern division, while 0.30 inch fell at Round Hill, in the northern division.

CLIMATOLOGY OF COSTA RICA.

Communicated by H. PITTIER, Director, Physical Geographic Institute.

[For tables see the last page of this REVIEW preceding the charts.]

Notes on the weather.—On the Pacific slope rain was rather scarce, although pretty continuous during the first half of the month. In San Jose the pressure was slightly under the normal; temperature higher; rainfall in deficit for about one-third of the average, with an excess of five days. On the Atlantic coast the rainfall was excessive, while it was deficient, although not scarce, at the stations of the interior at the foot of the Cordillera.

Notes on earthquakes.—November 16, slight shock at $6^h\ 2^m$ a. m., direction ENE–WSW, intensity II, duration 3 seconds. November 26, trepidatory movement at $1^h\ 40^m$ p. m., intensity III, duration 12 seconds. November 28, $9^h\ 45^m$ p. m., slight shock, N–S, intensity IV, duration 7 seconds. (The same day a slight shock was felt at Cachi at $9^h\ 45^m$ p. m., same direction).

ANNUAL WIND RESULTANTS.

By T. H. DAVIS, New Haven, Conn., dated February 20, 1902.

I do not believe that mathematical methods, inductive or deductive, will ever bring us to any clear conclusion as to the general circulation of the atmosphere, neither will it do to assume general physical laws as sufficient. The oscillatory movements and the progressive changes of winds can, I firmly believe, only be solved by careful, faithful observations and patient perseverance, and I respectfully submit the following contribution to the numerical method of treatment.

As a basis for a systematic investigation of annual frequencies of wind direction, I have used the directions recorded hourly, as given in full in the successive Annual Reports of the meteorological services of the United States and Canada, for the ten years 1891–1900; twenty-eight stations belong to the United States and six to Canada. From these I have computed the resultant directions, thereby obtaining figures that are as free as possible from the effect of the diurnal variation of the wind. The general method of computation is shown in the example copied in Table 1.

TABLE 1.—*Computation of annual resultant directions from hourly records of winds.*

BISMARCK, N. DAK.

Observed. Direction.	Observed. Number.	N.	E.	S.	W.
N	852	852			
NE	677	479	479		
E	1,266		1,266		
SE	1,060		749	749	
S	530			530	
SW	377			267	267
W	768				768
NW	3,033	2,149			2,144
Totals	8,563*	3,475	2,494	1,546	3,179
		1,546			2,494
Surplus		1,929			685
	Resultant......N. 21° W.				

*The difference between this number and the 8,760 hourly observations is due to calms and missing records.

All the resultants thus computed for each of the years 1891–1900 are given in Table 2. It will be noticed that instead of reckoning directions uniformly from the north point eastward around the circle I have started from either one of the four cardinal points, north, south, east, or west, as seemed most appropriate in each case. In general it will be seen that westerly winds have prevailed during this decade at all stations, except those in the region extending from Salt Lake City and Kansas

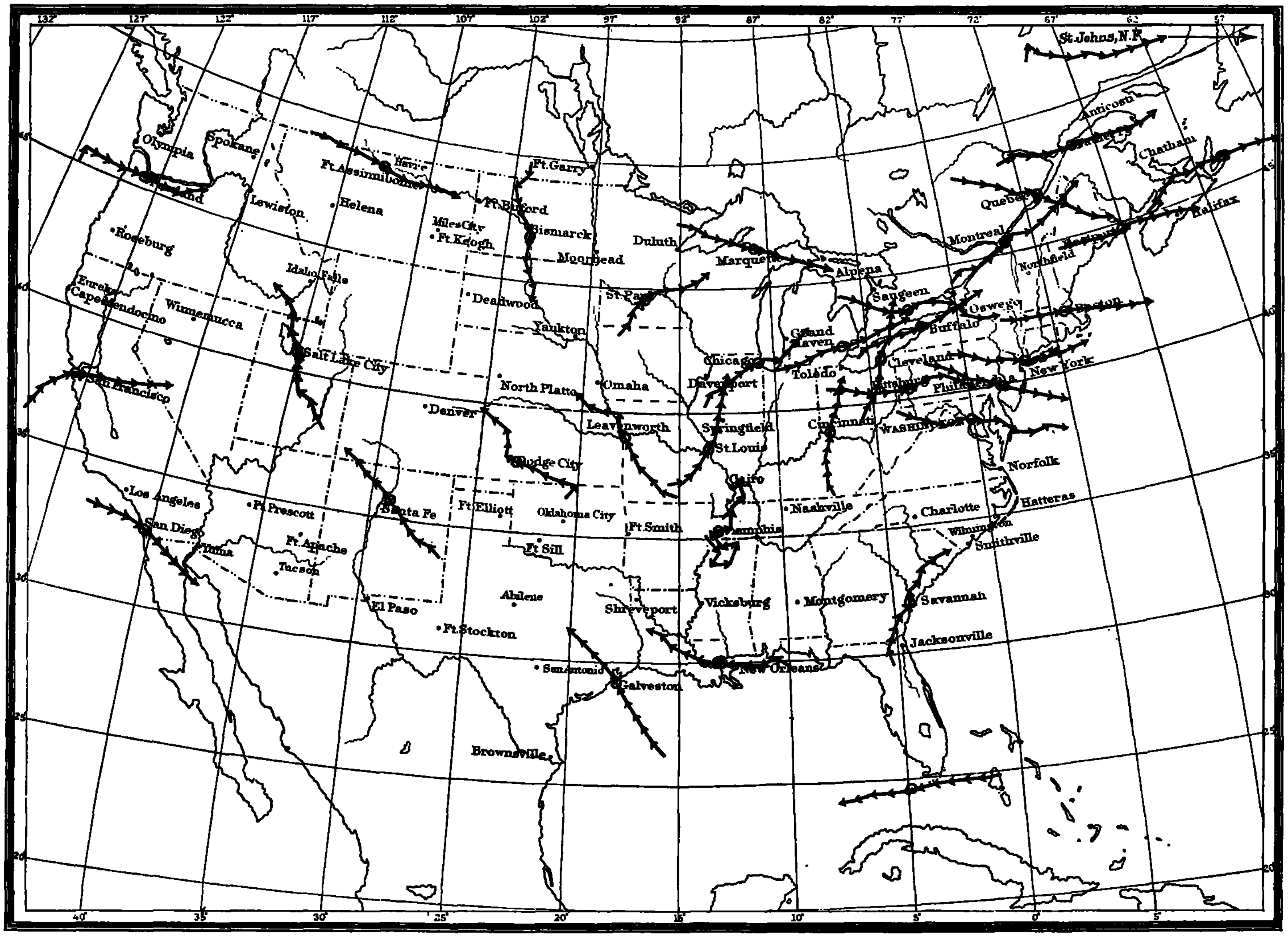

FIG. 1.—Davis's annual resultants of hourly wind directions.

City southeastward to New Orleans and Key West; in this region easterly and southerly resultants have prevailed.

It would also seem that these annual resultants must indicate some fundamental facts in atmospheric phenomena, and in order to critically study them I have plotted upon squared paper the angular directions considered as deviations from the adopted cardinal points, so that one perceives graphically the succession of changes from year to year. I regret that these diagrams are considered too voluminous to publish, but of course almost the same results can be obtained by a careful study of the numbers themselves, as given in Table 2. The changes of the resultants from year to year are sometimes progressive, but more often they suggest secular periodical changes in the circulation of the atmosphere. I have plotted all these resultants also on a chart of North America. (See fig. 1.) This chart shows ten short arrows at each station, following each other in regular succession and representing the individual resultants from 1891 to 1900. The central dot for any station is near the middle of its series of annual resultants. By studying these thirty-four separate series, we quickly see the geographical limits of the above-mentioned regions of easterly, southerly, and westerly resultants. By considering an imaginary straight line, representing the average resultant for each station, we perceive certain chronological laws, viz, that the individual years differ systematically first to the right and then to the left of this average value; these systematic deviations are closely analogous for stations that are near together, but have no apparent analogy when they are far apart. Possibly longer series of years will enable us to trace some important chronological law in the general circulation of the atmosphere, as shown by such annual resultants. Suggestions have been made as to the apparent influence of sun-spot periods, but I see no substantial evidence of this, and in fact the resultants for twenty or thirty years, or three sun-spot periods, would be needed in order to fully establish any such connection.

The extreme oscillations of the annual resultants from year to year during the decade in question are shown in Table 3 for each of the stations, and the general character of each oscillation and of the progressive motion is also stated therein.

In the preceding work I have employed complete sets of twenty-four observations daily, thereby eliminating any possible effect of the diurnal variation of the wind and securing perfect comparability in this respect for all the stations. But in order to study the possibility of a secular periodicity in the annual resultants, I have selected Key West as a station that is probably subject to less irregular variation than any other on the list in Table 2, and have computed for it the annual resultant for each year from 1873 to 1900. The results are given in Table 4, as also in fig. 2. Owing to changes in the hours of observation, these resultants may not be strictly comparable; in fact, the whole series is broken up into the following sections: 1873–1886, observations at 7 a. m., 2 p. m., and 9 p. m., Key West meridian time; 1887–88, observations at 7 a. m., 3 p. m., 10 p. m., seventy-fifth meridian time; 1889–90, observations at 8 a. m. and 8 p. m., seventy-fifth meridian time; 1891–1900, from anemograph records hourly, on seventy-fifth

TABLE 2.—*Resultant directions of wind.*

Station.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
	°	°	°	°	°	°	°	°	°	°
Bismarck, N. Dak	n. 11 e.	n. 41 e.	n. 20 w.	n. 17 w.	n. 37 w.	n.	n. 4 e.	n. 19 w.	n. 20 w.	n. 8 e.
Boston, Mass	w. 11 n.	w. 2 n.	w. 1 n.	w.	w. 6 n.	w. 13 n.	w. 8 n.	w. 8 n.	w. 1 n.	w. 7 n.
Buffalo, N. Y	w. 40 s.	w. 10 s.	w. 21 s.	w. 9 s.	w. 8 s.	w. 15 s.	w. 23 s.	w. 29 s.	w. 19 s.	w. 25 s.
Chicago, Ill	w. 64 s.	w. 17 s.	w. 45 s.	w. 43 s.	w. 27 s.	w. 23 s.	w. 5 n.	w. 45 s.	w. 56 s.	w. 42 s.
Cincinnati, Ohio	s. 22 e.	s. 9 w.	s. 7 e.	s. 16 w.	s. 21 w.	s.	s. 34 w.	s. 22 w.	s. 4 w.	s. 27 w.
Cleveland, Ohio	s. 30 w.	s. 45 w.	s. 23 w.	s. 12 w.	s. 9 w.	s. 27 w.	s. 36 w.	s. 10 w.	s. 14 w.	s. 20 w.
Detroit, Mich	w. 3 s.	w. 17 s.	w. 29 s.	w. 17 s.	w. 3 s.	w. 14 s.	w. 13 s.	w. 30 s.	w. 12 s.	w. 20 s.
Dodge, Kans	s. 35 w.	e. 7 s.	e. 13 s.	e. 30 s.	e. 14 s.	e. 24 s.	s. 5 w.	e. 83 s.	e. 29 s.	e. 37 s.
Eastport, Me	w. 3 n.	w. 7 n.	w. 7 n.	w. 6 s.	w. 20 s.	w. 6 n.	w. 3 n.	w. 3 s.	w. 10 n.	w. 10 n.
Galveston, Tex	e. 46 s.	e. 56 s.	e. 57 s.	e. 56 s.	e. 57 s.	e. 61 s.	e. 48 s.	e. 44 s.	e. 40 s.	e. 37 s.
Havre, Mont	*	w. 1 s.	w. 22 n.	w. 4 n.	w. 18 n.	w. 21 n.	w. 16 n.	w.	w. 2 n.	w. 10 n.
Kansas City, Mo	e. 19 s.	e. 46 s.	e. 44 s.	e. 63 s.	e. 62 s.	e. 63 s.	e. 86 s.	e.	e. 18 s.	e. 53 s.
Key West, Fla	e. 8 n.	e. 3 s.	e. 3 n.	e. 4 n.	e. 11 n.	e. 9 n.	e. 5 n.	e.	e. 12 n.	e. 8 n.
Marquette, Mich	w. 19 n.	w. 37 n.	w. 14 n.	w. 20 n.	w. 18 n.	w. 15 n.	w. 27 n.	w. 14 n.	w. 17 n.	w. 16 n.
Memphis, Tenn	w. 49 n.	e. 61 n.	w. 6 s.	w. 72 s.	e. 16 n.	e. 50 s.	w. 7 s.	w. 86 s.	w. 45 s.	e. 74 s.
New Orleans, La	e. 28 s.	e. 27 n.	e. 4 n.	e. 5 s.	e. 12 s.	e. 12 s.	e. 22 s.	e. 28 s.	e. 53 s.	e. 17 s.
New York, N. Y	w. 20 s.	w. 12 s.	w. 7 s.	w. 13 s.	w. 12 n.	w. 12 n.	w. 4 s.	w. 22 n.	w. 28 n.	w. 9 n.
Philadelphia, Pa	w. 23 n.	w. 30 n.	w. 39 n.	w. 14 n.	w. 28 n.	w. 24 n.	w. 25 n.	w. 20 n.	w. 22 n.	w. 21 n.
Pittsburg, Pa	w. 8 n.	w. 18 n.	w. 15 n.	w. 4 s.	w. 7 n.	w. 21 s.	w. 25 s.	w.	w. 29 n.	w. 29 n.
Portland, Oreg	w. 88 s.	w. 14 n.	w. 9 n.	w. 3 n.	w. 5 s.	w. 4 n.	w. 11 n.	w. 2 s.	w. 44 s.	w. 28 s.
St. Louis, Mo	w. 9 s.	w. 38 s.	w. 49 s.	w. 60 s.	w. 57 s.	w. 73 s.	w. 83 s.	w. 70 s.	w. 82 s.	w. 76 s.
St. Paul, Minn	†	†	w. 50 s.	w. 72 s.	w. 46 s.	w. 41 s.	w. 18 s.	w. 2 s.	w. 25 s.	w. 39 s.
Salt Lake City, Utah	s. 40 e.	s. 33 e.	s. 72 e.	s. 11 e.	s. 7 e.	s. 26 e.	s. 26 e.	s. 4 e.	s. 43 e.	s. 54 e.
San Diego, Cal	w. 10 n.	w. 6 n.	w. 9 n.	w. 17 n.	w. 25 n.	w. 32 n.	w. 33 n.	w. 28 n.	w. 30 n.	w. 28 n.
San Francisco, Cal	w. 22 s.	w. 22 s.	w. 46 s.	w. 47 s.	w. 11 s.	w. 8 s.	w. 2 s.	w. 14 s.	w. 17 s.	w. 11 s.
Santa Fe, N. Mex	e. 39 s.	e. 19 s.	e. 45 s.	e. 53 s.	e. 50 s.	e. 45 s.	e. 35 s.	e. 39 s.	e. 55 s.	e. 31 s.
Savannah, Ga	s. 8 e.	s. 21 w.	s. 21 w.	s. 29 w.	s. 43 w.	s. 6 w.	s. 51 w.	s. 20 w.	s. 50 w.	s. 68 w.
Washington, D. C	w. 31 n.	w. 23 n.	w. 25 n.	w. 11 s.	w. 20 n.	w. 11 n.	w. 45 n.	w. 11 n.	w. 10 s.	w. 16 n.
Montreal, Que	w. 40 s.	w. 6 n.	w. 26 s.	w. 35 s.	w. 36 s.	w. 4 n.	w. 28 s.	w. 34 s.	w. 34 s.	w. 34 s.
Quebec, Que	w. 23 n.	w. 24 n.	w. 27 n.	w. 41 n.	w. 7 n.	w. 46 n.	w. 23 n.	w. 44 n.	w. 26 n.	w. 12 n.
Father Point, Que	w. 6 s.	w. 23 n.	w. 10 n.	w. 4 n.	w. 8 s.	w. 3 n.	w. 9 n.	w.	w. 4 s.	w. 15 s.
St. Johns, N. F	w. 53 s.	w. 63 n.	w. 30 n.	w. 30 n.	w.	w. 34 n.	w. 3 n.	w. 4 s.	w. 4 n.	w.
Toronto, Ont	w. 22 n.	w. 37 n.	w. 25 n.	w. 10 n.	w. 21 s.	w. 4 n.	w. 19 n.	w. 54 n.	w. 21 n.	w. 2 n.
Sydney, N. S	w. 33 s.	w. 39 s.	w. 23 s.	w. 8 n.	w. 17 s.	w. 3 n.	w. 1 s.	w. 2 s.	w. 3 n.	w. 6 n.

*Report incomplete. †Doubtful.

meridian time. In order to get some idea of the effect of using twenty-four hourly observations instead of two or three, I have for the years 1895–1899 computed the resultants for two observations per day, 8 a. m. and 8 p. m., standard time, with the following results: 1895, E. 15° N; 1896, E. 12° N.; 1897, E. 6° N.; 1898, E. 4° N.; 1899, E. 16° N. By comparing these with the resultants given in Table 4, it appears therefore that the resultant of 8 a. m. and 8 p. m. is almost uniformly 4° farther north than the resultant of twenty-four hourly observations. This small constant difference will not affect the general result deducible from Table 4 and fig. 2, viz, that the annual resultant winds at Key West fluctuate in a systematic manner, having been farthest north of east at about 1873.0, 1877.5, 1886.0, 1895.0, and 1899.5. The average of these extreme northerly resultants is about E. 14° N. The annual resultants have been farthest south about 1875.5, 1880.0, 1892.0, and 1898.0. The average of these extreme southerly annual resultants is about 1° south of east.

The maxima and minima of Wolfer's sun-spot numbers are published in the MONTHLY WEATHER REVIEW for April, 1902, and we quote the dates from page 176, as follows:

Minimum, 1867.2; maximum, 1870.6; minimum, 1878.9; maximum, 1883.9; minimum, 1889.6; maximum, 1894.1; minimum, 1901.5. There is no apparent causal connection between these dates and those of the extreme deviations of the resultant winds at Key West.

In order to extend the investigation to another supposedly quiet region, I have also computed the resultants of all winds observed in the Bermudas during the years 1889–1900. The resultants are shown in fig. 3, from which it will be seen that the range of direction has been unexpectedly great, viz, from west 75° south, in 1895, to west 1° south, in 1898. Here again I could use but a few observations daily instead of hourly records, but I see no reason to doubt the general accuracy of the result, and this great range occurs without special connection with either a maximum or minimum of sun spots.

In order to compare the wind resultants at low stations with those that obtain at the highest stations, I have computed the resultants for Mount Washington, 1877–1886, and Pikes Peak, 1876–1887. The results are shown on fig. 4. Of course, these computations have been based entirely upon tridaily observations; but this can not alter the general conclusion that when

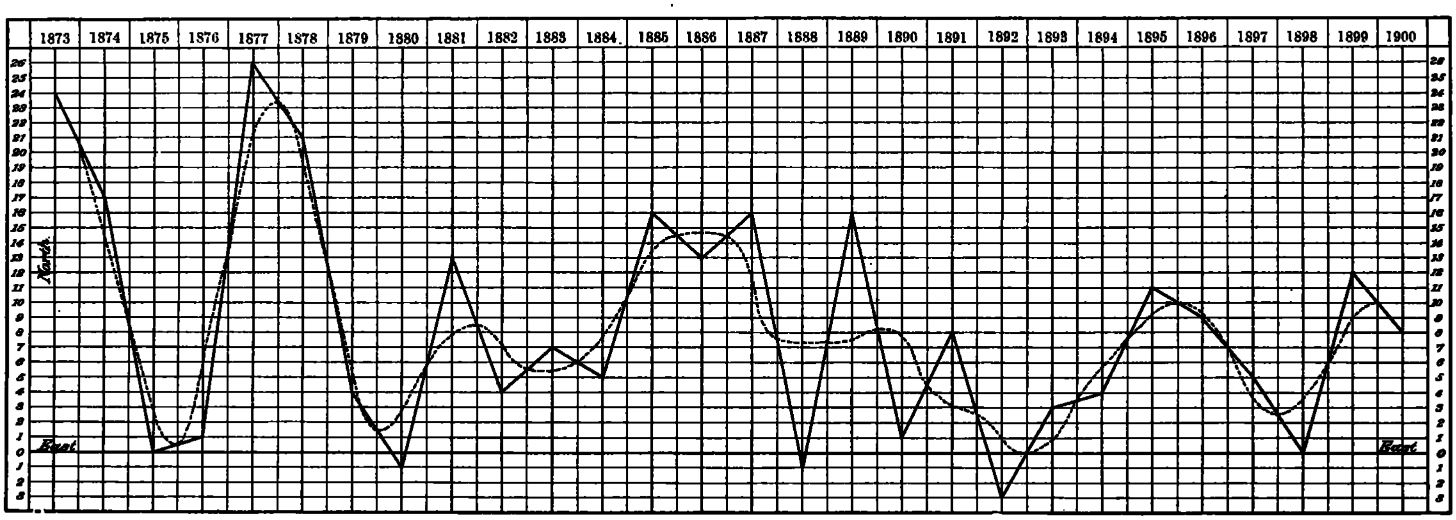

FIG. 2.—Davis's resultants of all observations of winds at Key West, Fla.

the resultants are most northerly at one station they are most southerly at the other and vice versa.

The remarkable relations revealed by these tables and charts show that the natural relations of the winds are complex and still obscure. I see no indication of a sun spot nor of a lunar influence. To what natural laws or combinations of laws are we to attribute these variations in the annual resultants?

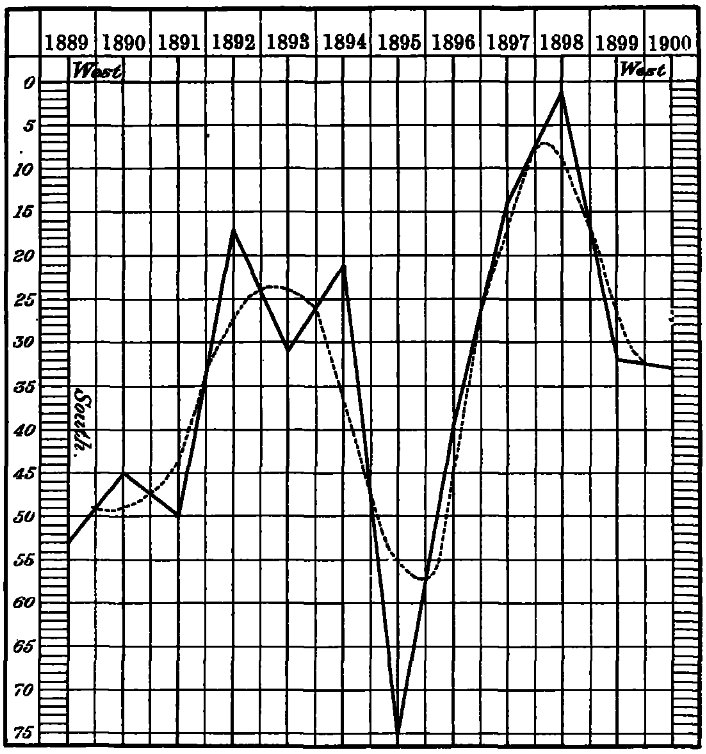

FIG. 3.—Resultants of all observations of winds at Bermuda.

TABLE 3.—*Ranges of annual resultants in the United States and Canada.*

Station.	Annual oscillation, mean curve.	Variation of resultant from east or west. Maximum degree and direction.	Year.	Minimum degree and direction.	Year.	Range.	Tendency of progression north or south. (See charts.)
		°		°		°	
Bismarck, N. Dak	Regular	e. 41 n.	1892	w. 53 n.	1895	78	n.
Boston, Mass	do	w. 13 n.	1896	w.	1894	13	n.
Buffalo, N. Y	Irregular	w. 40 s.	1891	w. 8 s.	1895	32	n.
Chicago, Ill	do	w. 64 s.	1891	w. 5 n.	1897	69	s.
Cleveland, Ohio	Regular	w. 81 s.	1895	w. 45 s.	1892	36	s.
Cincinnati, Ohio	do	e. 68 s.	1891	w. 63 s.	1897	49	n.
Detroit, Mich	do	w. 30 s.	1898	w. 3 s.	1891, 1895	27	s.
Dodge, Kans	Irregular	w. 85 s.	1897	e. 7 s.	1892	88	s.
Eastport, Me	do	w. 20 s.	1895	w. 3 s.	1898	30	n.
Galveston, Tex	Regular	e. 61 s.	1896	e. 37 s.	1900	24	n.
Havre, Mont	Irregular	w. 22 n.	1893	w.	1898	23	s.
Kansas City, Mo	do	e. 86 s.	1897	e.	1898	86	n.
Key West, Fla	do	e. 26 n.	1877	e.	1875, 1898	29	
Marquette, Mich	do	w. 37 n.	1892	w. 14 n.	1893, 1898	23	s.
Memphis, Tenn	do						
New Orleans, La	do	e. 53 s.	1899	e. 5 s.	1894	80	s.
New York, N. Y	Regular	w. 28 n.	1899	w. 4 s.	1897	48	n.
Philadelphia, Pa	Irregular	w. 39 n.	1893	w. 14 n.	1894	25	s.
Pittsburg, Pa	do	w. 30 n.	1899	w. 4 s.	1894	55	n.
Portland, Oreg	do	w. 44 s.	1899	w. 5 s.	1895	58	s.
St. Louis, Mo	Regular	w. 83 s.	1897	w. 9 s.	1891	74	s.
St. Paul, Minn	do	w. 72 s.	1894	w. 2 s.	1898	70	n.
Salt Lake City, Utah	Irregular	e. 86 s.	1898	e. 18 s.	1893	68	s.
San Diego, Cal	Regular	w. 33 n.	1897	w. 6 n.	1892	27	n.
San Francisco, Cal	do	w. 47 s.	1894	w. 2 s.	1897	45	n.
Santa Fe, N. Mex	do	e. 55 s.	1899	e. 19 s.	1892	36	s.
Savannah, Ga	Irregular	w. 84 s.	1896	w. 22 s.	1900	62	n.
Washington, D. C	Regular	w. 45 n.	1897	w. 10 s.	1899	56	s.
St. Johns, N. F	Irregular	w. 63 n.	1892	w.	1900	67	s.
Sydney, C. B. I	do	w. 39 s.	1892	w. 2 s.	1898	47	n.
Father Point, Que	Regular	w. 23 n.	1892	w.	1898	78	s.
Quebec, Que	Irregular	w. 46 n.	1896	w. 7 n.	1895	39	
Montreal, Que	Regular	w. 40 s.	1891	w. 4 n.	1896	46	s.
Toronto, Ont.	do	w. 54 n.	1898	w. 4 n.	1896	75	n.

The locations of the general areas of high and low pressure or the general trend of isobars at any time has a definite influence on the winds of that date; so, also, these resultants have some relation to the annual or normal isobars; but the outstanding discrepancies are still very great. The primary consideration in explaining these must be the permanent location and influence of the continents and oceans and the temporary influence of the areas of high and low pressure that move about just enough to justify their being known as subpermanent tropical areas. The effect of the diurnal land and sea breezes and the annual monsoon winds seems to be inappreciable.

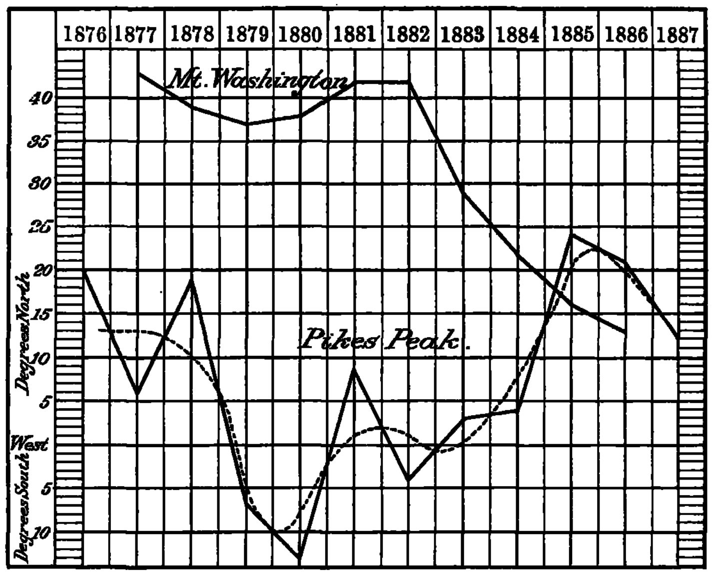

FIG. 4.—Resultants of all winds at Mount Washington and Pikes Peak.

TABLE 4.—*Key West resultants.*

Year.	Direction from—	Year.	Direction from—	Year.	Direction from—
	°		°		°
1873	e. 24 n.	1883	e. 7 n.	1892	e. 3 s.*
1874	e. 17 n.	1884	e. 5 n.	1893	e. 7 n.*
1875	east.	1885	e. 16 n.	1894	e. 4 n.*
1876	e. 1 n.	1886	e. 13 n.	1895	e. 11 n.*
1877	e. 26 n.	1887	e. 16 n.	1896	e. 9 n.*
1878	e. 21 n.	1888	e. 1 s.	1897	e. 5 n.*
1879	e. 4 n.	1889	e. 16 n.	1898	east.*
1880	e. 1 s	1890	e. 1 n.	1899	e. 12 n.*
1881	e. 13 n.	1891	*e. 8 n.	1900	e. 8 n.*
1882	e. 4 n.				

* The resultants for 1891-1900 are those deduced from the hourly observations.

THE CLIMATOLOGY AND WATER POWER OF PORTO RICO.

By WM. H. ALEXANDER, Observer, Weather Bureau, dated December 29, 1902.

The climatology of Porto Rico is, in several respects, unknown and the island is therefore to some extent a new meteorological field. It is certainly a most inviting one to the student of tropical meteorology, as it presents in a small space many of the most interesting problems. It possesses a singularly peculiar topography which creates surprising local climatic differences. Analogous differences moreover characterize more or less the geological structure, the composition of the soil, the flora, and the hydrography of the island. For instance, the island, small as it is, has a range in the extremes of precipitation (that is, the difference between the amounts of greatest and least precipitation at different places) almost if not quite as great as is to be found in the whole of the United States. These differences are so pronounced and important that they can not be ignored when considering the agricultural possibilities and water resources of the island and must be taken into account in all problems relative to irriga-